



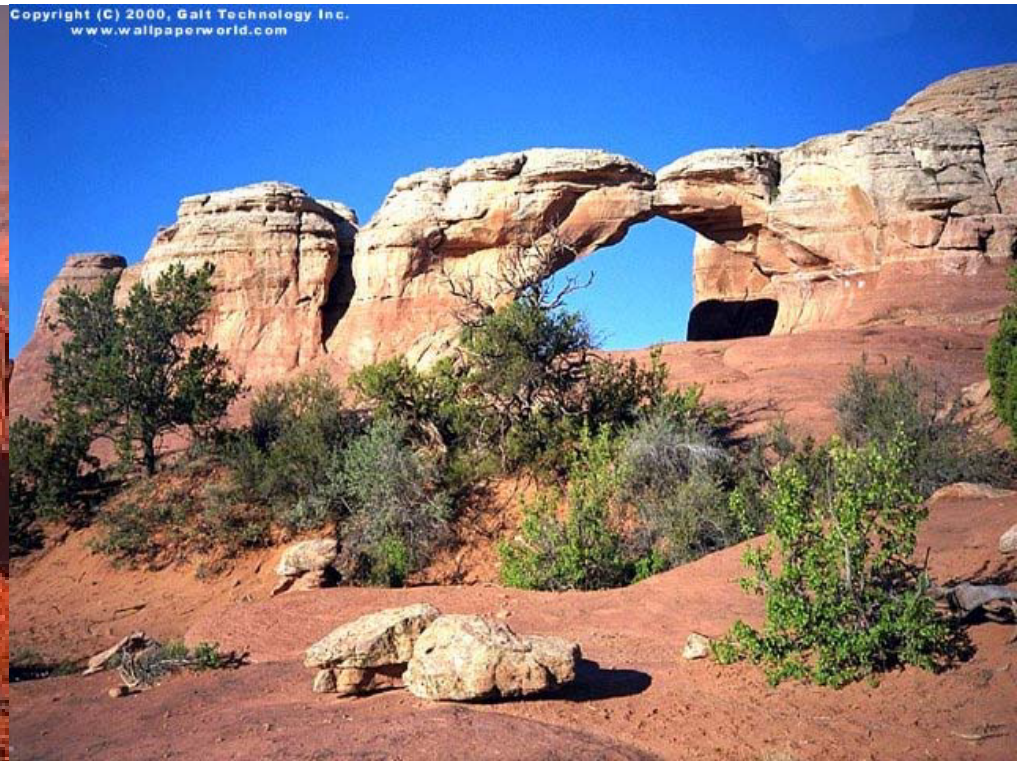
# Introduction to Soils

# Soil Formation

- ◆ Soil is defined as the entire unconsolidated material that overlies and is distinguishable from bedrock.
- ◆ Composed of loosely bound mineral grains of various sizes and shapes.
- ◆ Contains voids of varying sizes. These voids contain:
  - Air
  - Water
  - Organics

# Soil Formation - Weathering

- ◆ The principal factor by which rock is converted into soil.



# Soil Formation - Weathering

## ◆ Two types:

### ■ Physical

- ◆ breaks rock masses into smaller pieces without altering the chemical composition of the pieces.

### ■ Chemical

- ◆ decomposition of rock through the chemical reactions that take place between minerals of the rock and the air, water or dissolved chemicals in the atmosphere



# Physical Weathering

◆ **Unloading** – fracturing; removal of overlying material



Exfoliation slabs, Enchanted Rock State Park, Texas

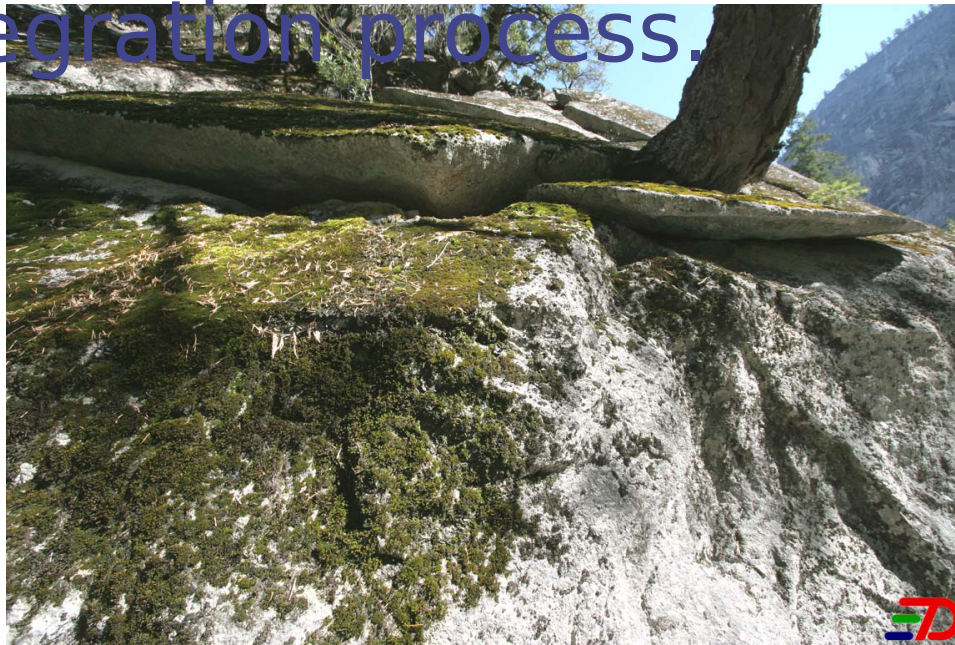
# Physical Weathering

- ◆ **Frost Action** – trapped moisture in rocks freeze. Moisture expand to 1/10 of its original volume, creating pressure of up to 4000 psi



# Physical Weathering

**Organism Growth**—wedging action caused by tree and plant root growth in the joints of rock hastens the disintegration process.





# Physical Weathering

- ◆ **Abrasion** – Sediments suspended in wind or fast-moving water. Rock particles carried by glacial ice.



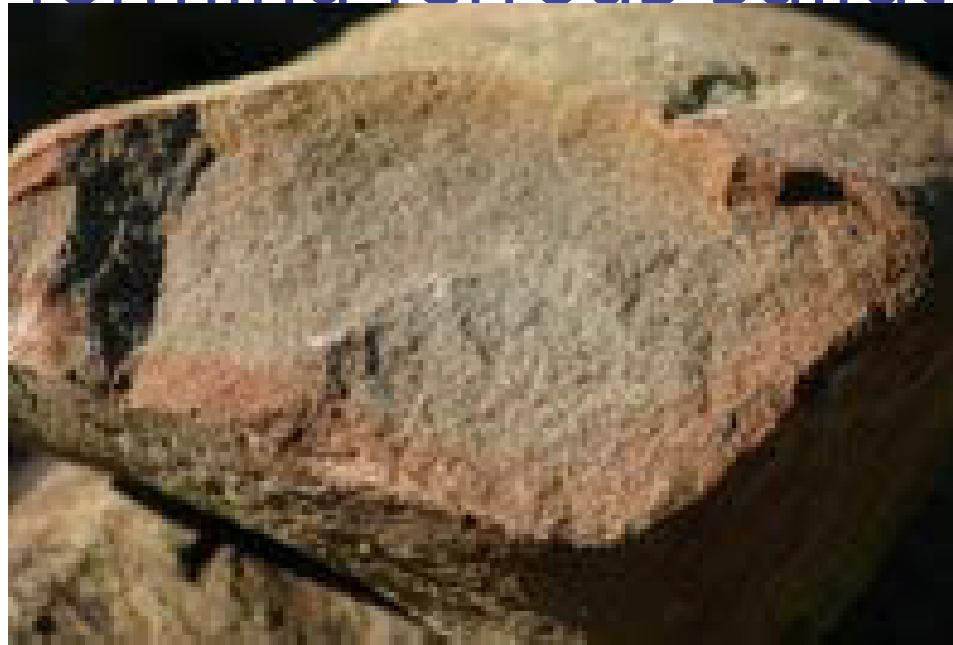
Boulders rounded by impacts and abrasion

# Chemical Weathering

- ◆ Decomposition of rock through chemical bonding
- ◆ Examples include:
  - Hydration (combining with water)
  - Oxidation
  - Carbonation (saturation with carbon dioxide)

# Chemical Weathering

◆ **Oxidation** – chemical union of a compound with oxygen; e.g. rusting, chemical reaction of oxygen, water and the iron mineral pyrite forming ferrous sulfate.



# Chemical Weathering

◆ **Hydration** – chemical union of a compound with water.





# Chemical Weathering

◆ **Carbonation** – CO<sub>2</sub> from the air unites with various minerals to form carbonates

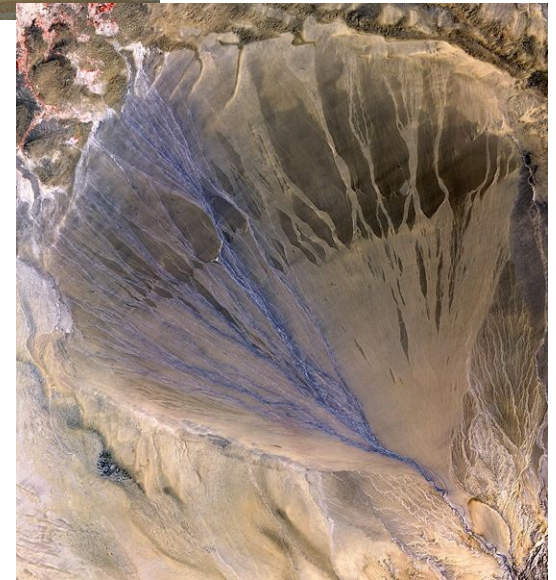


# Soil Formation - Methods

◆ **Residual Soils** –  
weathered in  
place.



◆ **Transported Soils** –  
glacial ice, water and  
wind – agents.



# Questions?

- What are the two types of weathering called?
- What are the two types of soil formation methods?

# Soil Characteristics

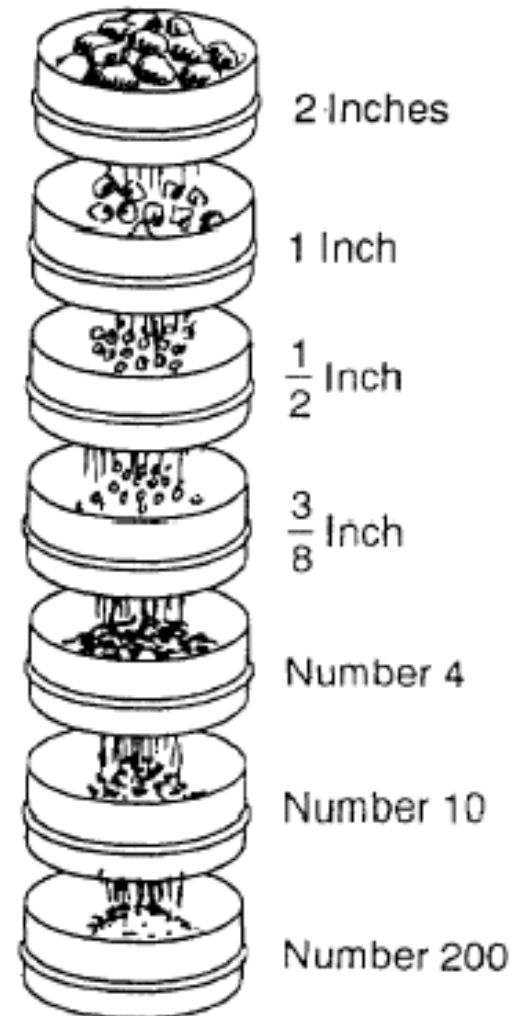
## ◆ PHYSICAL

- **GRAIN / PARTICLE SIZE**
- **GRAIN / PARTICLE SHAPE**

# Soil Characteristics – Sieve Analysis

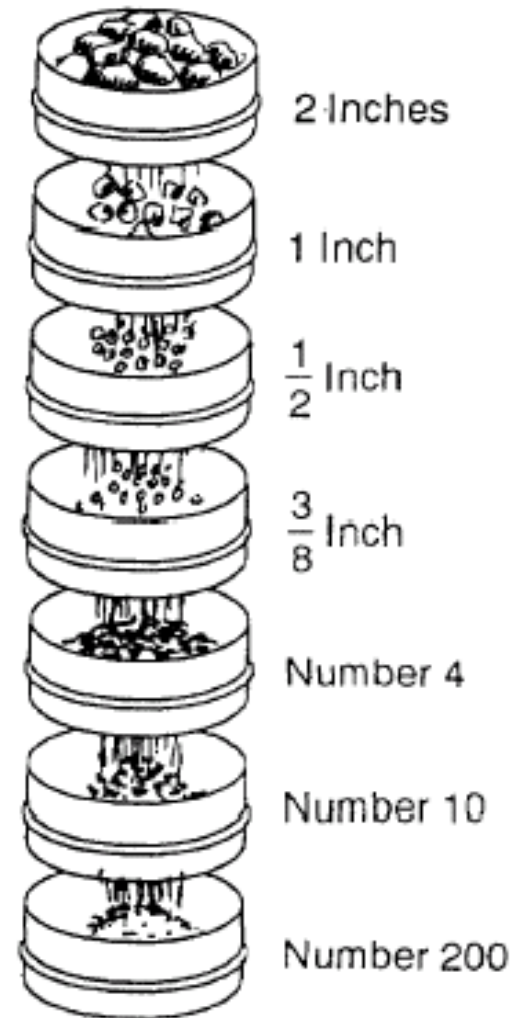
**INCH SIEVES**  
Ranging from 3" - 1/4"

**NUMBERED SIEVES**  
Ranging from # 4 - # 200

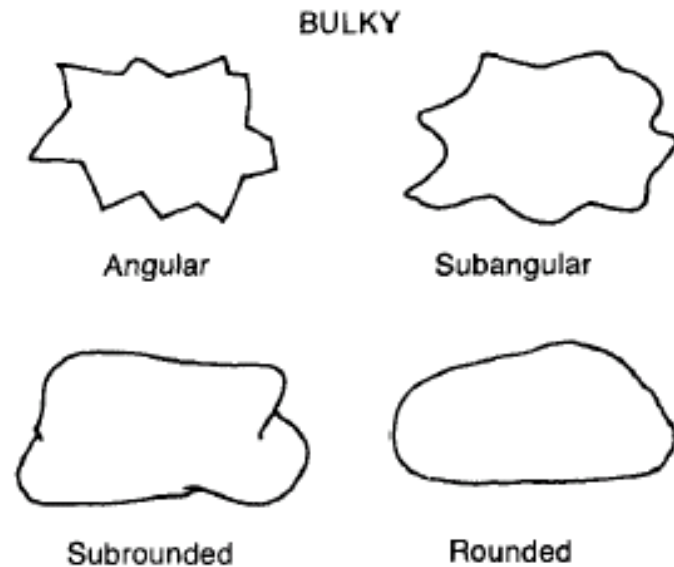


# Soil Characteristics - Grain/Particle SIZE

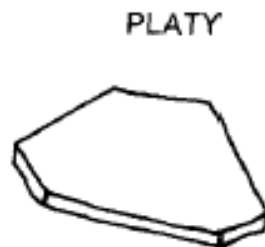
- ◆ Four major SIZE groups:
- Cobbles – greater than 3"
  - Gravels – Passes a 3" sieve and retained on No.4 sieve (approx 0.25")
  - Sands – Passes No.4 sieve and retained on No. 200 sieve (0.072 mm)



# Soil Characteristics – Grain/Particle SHAPE



subdivided depending  
on the amount of  
weathering that has  
acted on them



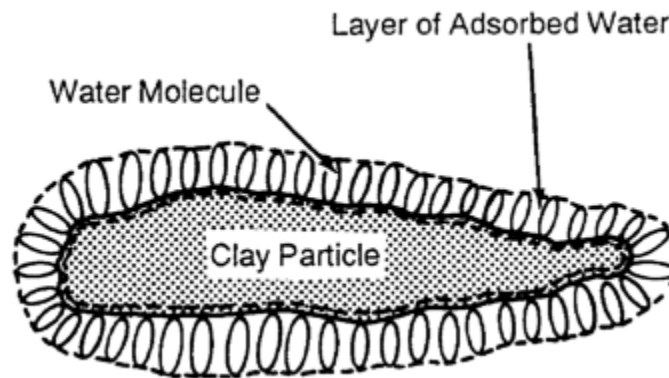
- Extremely thin compared to their length and width.
- Only fine grained material of the clay variety has this characteristic shape.
- Platy grains are responsible for the plasticity of clay.
- Highly compressible under static load<sup>18</sup>



# Grain/Particle SHAPE - Platy

## ◆ **PLATY SHAPES**

### ◆ **PRIMARILY GRAINED MATERIAL OF THE CLAY VARIETY**



- In general, the higher the moisture content of clay or silt, the less its strength and bearing capacity.

# Soil Characteristics

## ◆ GRADATION

◆ distribution of particle sizes within a soil mass.



Well-graded soil.



Uniformly graded soil.



Gap-graded soil.

# Questions?

- How is particle size determined?
- What are the two types of poorly graded soil?



# Soil Classification

## UNIFIED SOILS CLASSIFICATION SYSTEM (USCS)



# Soil Classification- USCS

## ◆ COARSE GRAINED

◆ Gravel / Sand

## ◆ FINE GRAINED

◆ Silt / Clay

## ◆ PEAT

◆ Organic Material

# Soil Classification- USCS

Soil Groups	Symbol	Remarks
Gravel	G	Primary only
Sand	S	Primary only
Silt	M	Primary and secondary
Clay	C	Primary and secondary
Organic (silts or clays)	O	Primary only
Highly Organic (peat)	Pt	Stands alone

# Soil Classification- USCS

Soil Characteristics	Symbol	Remarks
Well graded	W	Secondary only
Poorly graded	P	Secondary only
Low liquid limit (less than 50)	L	Secondary only
High liquid limit (50 or greater)	H	Secondary only



# Questions?

- What is the USCS based on?
- What is the symbol for gravel based of the USCS?

# Field Identification of Soil

## ◆ Useful Sources of Information

- ◆ S-2 Intelligence Report
- ◆ Local Inhabitants
- ◆ Maps and Aerial Photos

## ◆ Soil Exploration

- ◆ Surface Sample
- ◆ Existing Excavations
- ◆ Test Hole

# KSE K-2009 SOIL TEST SET



LABORATORY

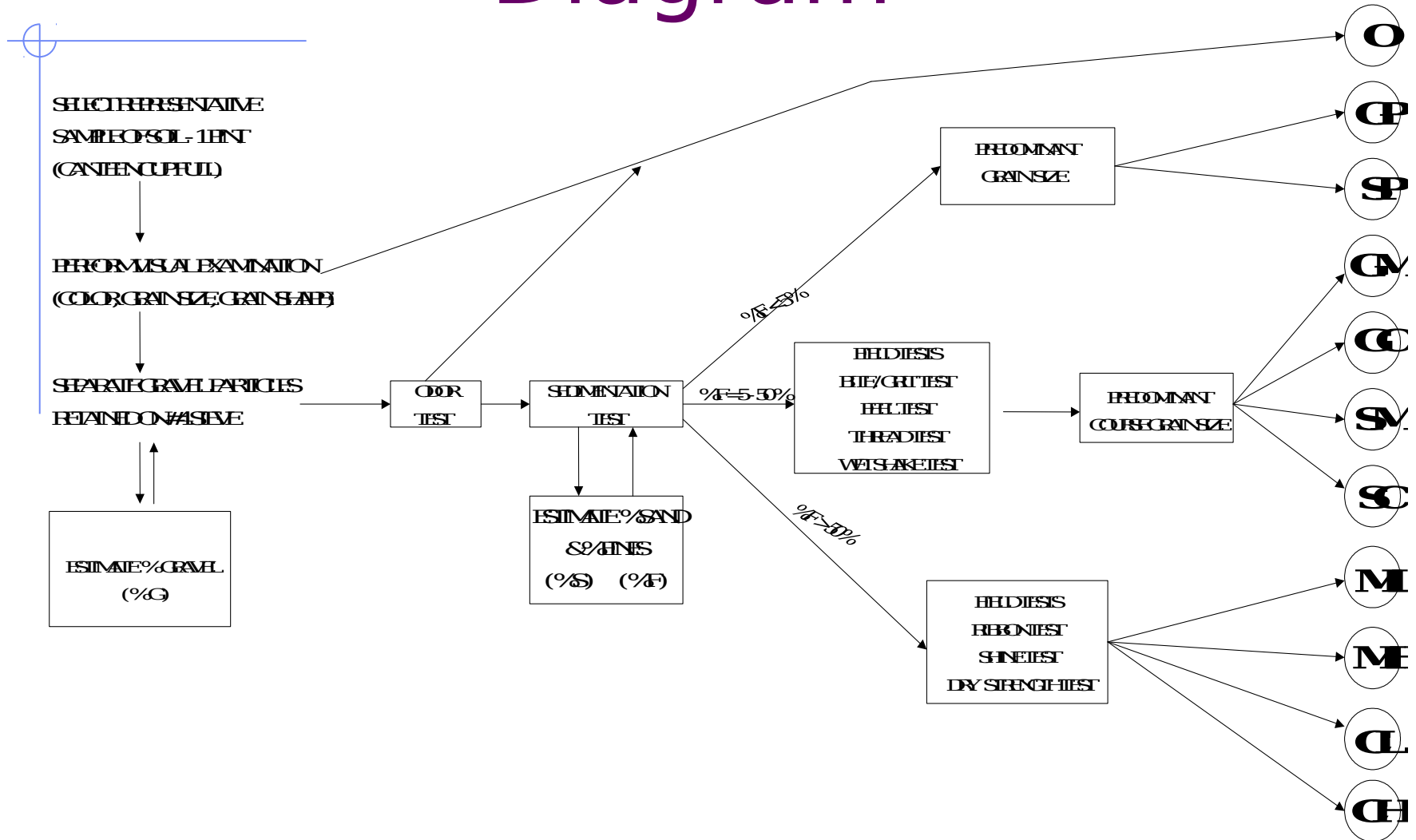


SPEEDY  
MOISTURE  
TESTER



DYNAMIC CONE  
PENETROMETER

# Soil Classification Wire Diagram



# Questions



# Demonstration



# Practical Application






# Bearing Capacity

# Bearing Capacity

- ◆ The ability of a soil to support a load applied by an engineering structure.
- ◆ A soil with insufficient bearing capacity might fail, by shear, allowing the structure to sink and shift.
- ◆ Dense and well graded soil with angular particles generally has good bearing capacities.







# California Bearing Ratio (CBR)

# CBR

- ◆ **Used to measure bearing capacity**
- ◆ **CBR is a comparison of soil to crushed limestone**
- ◆ **CBR is expressed as a percentage**
- ◆ **Determined using the Dual Mass Dynamic Cone Penetrometer (DCP)**

# Dynamic Cone Penetrometer



Rod Assembly & Dual Mass Hammer

Set Pins & Clips,  
Allen Wrench

Magnetic ruler  
w/  
Digital Assembly

# DCP

◆ **Used To estimate strength characteristics of:**

- **Fine and course grained soils**
- **Granular construction materials**
- **Weakly stabilized or modified materials**
- **Soils under stable layer (by drilling access hole)**



# DCP

## ◆ **Operations - Pre Ops Inspection**

- **Normal, wear, tear, and fatigue expected**
- **Ensure joints tight - use loctite and tools**
- **Ensure points are within tolerance, check with go-no go**

# DCP

## ◆ Two Man Ops

- Marine - 1**
- Hold device in place by handle in vertical position
  - Tap device (hammer) till top of cone flush with soil
    - Start hammer process
    - Lift hammer, drop hammer

- Marine - 2**
- Check device for zero reading
  - Hold vertical scale between soil surface and bottom

of hammer

- Records:
  - number of hammer blows
  - depth of penetration

# Data Recording - Manual

## ◆ Manual recording of CBR data



# DCP

## DCP DATA SHEET

Project:

Location:

Depth of zero point below surface:

Material Classification:

Pavement conditions:

Date:

Personnel:

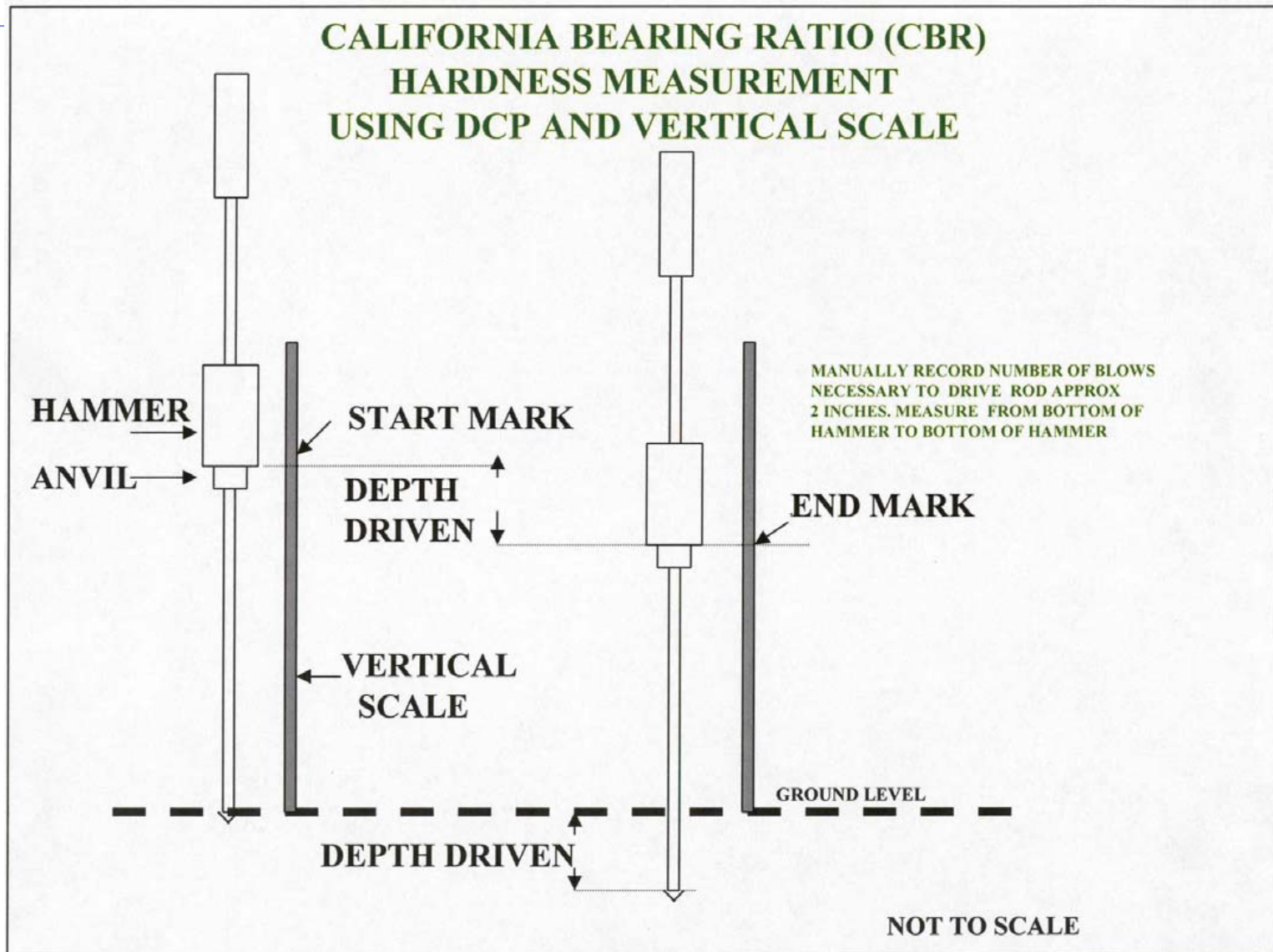
Hammer Weight:

Weather:

Water Table Depth:

#	(1) Number of Blows	(2) Cumulative Penetration (mm)	(3) Penetration Between Reading (mm)	(4) Penetration per Blow (mm)	(5) Hammer Blow Factor	(6) DCP Index mm/blow	(7) CBR %	(8) Moisture %
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								

# (CBR) Hardness Measurement - Manual





# Questions?

# Data Acquisition System (DAS)



# DAS

- ◆ **Records data from DCP test**
- ◆ **Communicates with and records data from Soil Moisture Probe (SMP)**
- ◆ **Can store up to 8 hours of test data**
- ◆ **Can download to a computer**

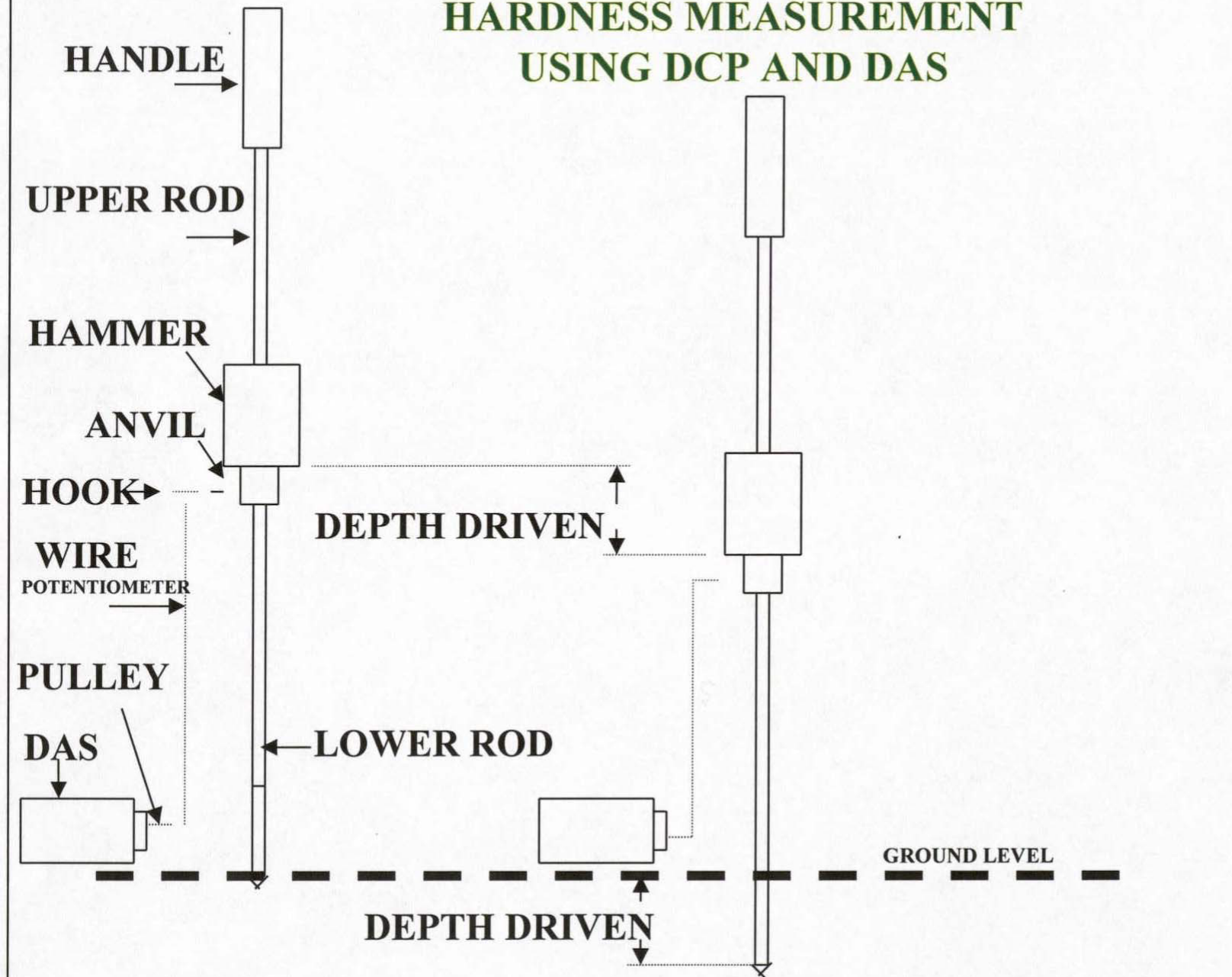




# **WARNING**

**Never let the depth gauge string retract unrestricted, as this will damage the depth transducer.**

# CALIFORNIA BEARING RATIO (CBR) HARDNESS MEASUREMENT USING DCP AND DAS



NOT TO SCALE



# Questions?



# Soils Moisture Probe

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**(SMP)**

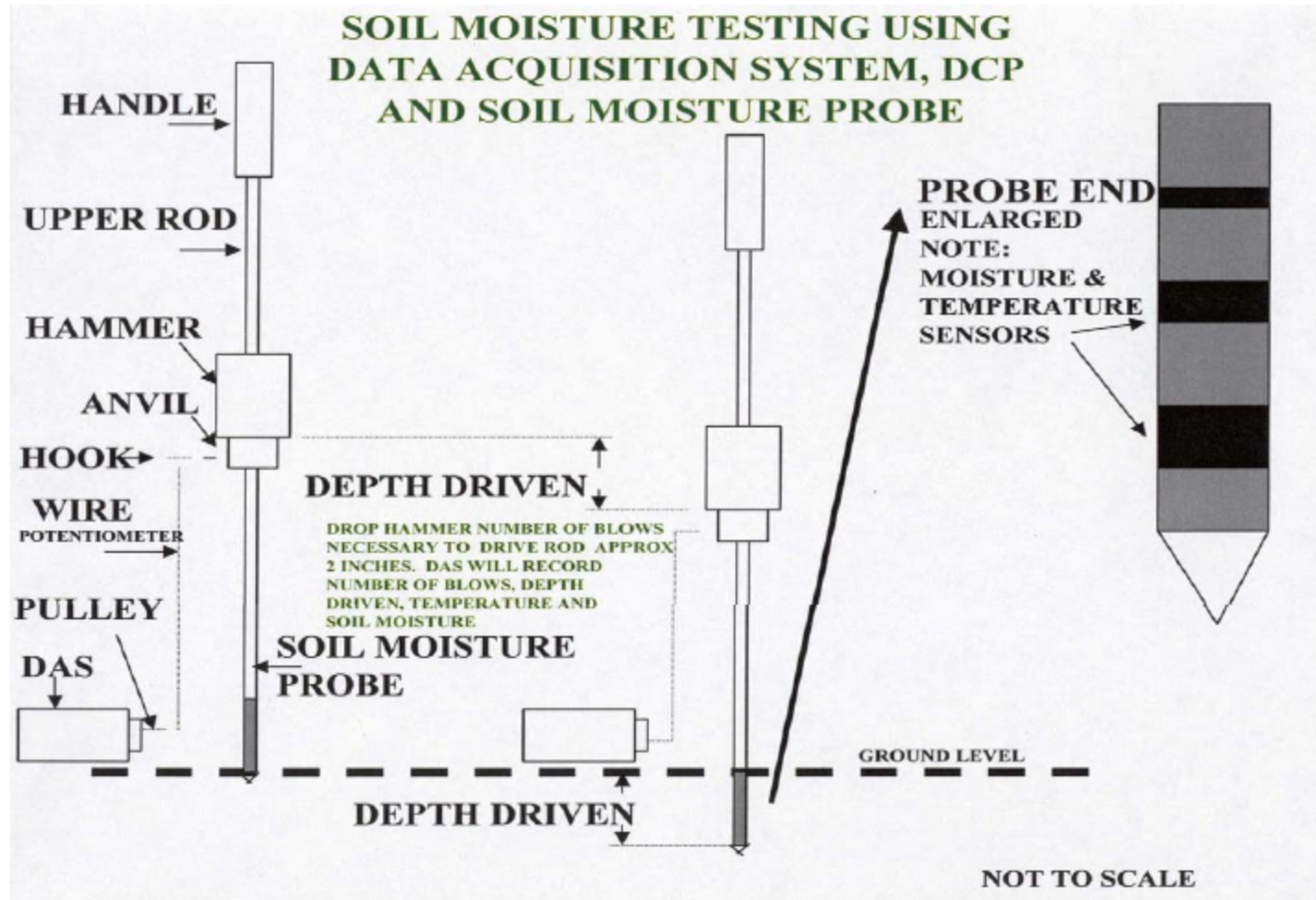
**Multifunctional:**

**Soil Moisture**

**Soil Temperature**

**Sends data to the DAS**

# SMP



# Speedy Moisture Tester

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- Used to test soil Moisture
- Used with Calcium Carbide reagent
- 0-40% moisture range
- 26 grams sample or 13 grams if over 20%
- 1 or 3 minute test.



# QUALITY CONTROL

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- TEST STRIP
- SPEEDY MOISTURE TESTER
- DM-DCP WITH SMP & DAS



# Demonstration / Practical Application



# Questions?

- What two methods are used for the sedimentation test?
- What is California Bearing Ratio use to determine?

# Summary

- How soil is formed.
  - Composition of a soil mass.
  - How to conduct a hasty field I.D. on a previously unknown soil.
- 
- IRF